2-1977

A Comparative Analysis of Tests for Central Auditory Function and Tests for Auditory Processing

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Abstract

A COMPARATIVE ANALYSIS OF TESTS FOR CENTRAL AUDITORY FUNCTION AND TESTS FOR AUDITORY PROCESSING

by Lynnee C. Luckett

The purpose of the present investigation was to determine whether there was a relationship between the results obtained from tests of auditory language performance and those obtained from tests of central auditory performance. The performances of ten learning disabled children were compared with the performances of ten normal achievers on the six auditory language subtests of the Illinois Test of Psycholinguistic Abilities and the staggered spondaic word test and Willeford's tests of central auditory processing abilities. The two groups were matched according to sex, age, and socioeconomic status. Only children having normal peripheral hearing and an IQ within normal range were included in the investigation. The results of the two test batteries were analyzed statistically using a t-test for related samples, a correlation matrix and a regression analysis.

The findings of the study revealed that: (1) the experimental and control groups differed significantly on the auditory reception subtest of the ITPA and the filtered speech portion of Willeford's tests for central auditory processing abilities. No other significant differences were found for any of the other tests; (2) both the experimental and control groups obtained scores which were below the normal range of performance as set by the authors of the central auditory tests. These results indicate that all subjects in the investigation were exhibiting central auditory problems; (3) in

an attempt to predict performance on the central auditory tests, it was found that a combination of the auditory sequential memory and auditory closure subtests of the ITPA predicted performance on the staggered spondaic word test. It was also revealed that the auditory sequential memory subtest of the ITPA predicted performance on the binaural resynthesis part of Willeford's tests. These were the only predictors identified; and (4) the low socioeconomic status of the subjects did not appear to affect their performance on the ITPA. It is possible that the low socioeconomic status of the subjects was a contributing factor to their low performance on the central auditory tests. However, the lower scores may simply reflect the age of the subjects, a factor which was not considered when the norms of the central auditory tests were established.

The implications of these findings are that: (1) one set of norms for all age groups may not be adequate enough to differentiate abnormal from normal in the area of central auditory performance; (2) the small number of predictors between the auditory language tests and the central auditory tests may indicate that these two types of tests are tapping into different systems and evaluating two different kinds of auditory processing; and (3) when working with children who have been identified by the SSW as having central auditory difficulty, incorporation of tasks stressing auditory memory and filling in missing auditory cues may aid in the overall rehabilitation of these children.

A COMPARATIVE ANALYSIS OF TESTS FOR CENTRAL AUDITORY FUNCTION AND TESTS FOR AUDITORY PROCESSING

A Thesis

Presented to

the Faculty of the Graduate School

Loma Linda University

In Partial Fulfillment

of the Requirement for the Degree

Master of Science

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by

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February 1977

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Chapter 1

INTRODUCTION

Recently, there have been studies in the area of learning disabilities by both audiologists and speech pathologists in relationship to central auditory processing. In the past central auditory procedures were not used to diagnose learning disabled children. This was due to the fact that learning disabled children typically manifested normal pure tone configurations and discrimination scores. Therefore, the difficulties exhibited by these learning disabled children were not considered to be part of an auditory deficit. However, during the past few years, a possible connection has been seen between learning disabilities and central auditory dysfunction. Audiologists are now conducting investigations in this area.

Various methods of testing have been used in measuring auditory function, including tests of filtered speech, competing messages, binaural fusion and alternating speech. Those tests which put stress on the auditory system by reducing the redundancy of speech appear to be the most successful in identifying central auditory nervous system dysfunction. It is reported that tests of the central auditory system measure function at the brain stem and/or at the auditory cortex, depending on the type of test administered.

Speech pathologists and linguists have also investigated the function of the auditory system of learning disabled children. Perhaps the most commonly used measurement of auditory processing in the field

of speech pathology is the Illinois Test of Psycholinguistic Abilities (ITPA). This test has ten subtests and two supplementary tests, six of which are reported to tap into the auditory processing system. Auditory stimuli are presented in the form of phrases, sentences or digits to which the child must give an appropriate response. Children who have auditory deficits (excluding peripheral hearing loss) tend to perform poorly on the auditory subtests of the ITPA.

It can be seen that both audiologists and speech pathologists measure the function of the auditory processing system. Audiologists use such tests as the staggered spondaic word test (SSW) and Willeford's tests of central auditory processing abilities. Speech pathologists use such tests as the auditory subtests of the ITPA. Is it possible that both audiologists and speech pathologists are testing the same auditory characteristics in learning disabled children? If so, there should be some measurable correlation between the results obtained by both audiologists and those obtained by speech pathologists in the area of central auditory functioning.

Statement of the problem

Both audiologists and speech pathologists are administering tests which are reported to test auditory processing. It was not yet determined if the results of these two batteries of tests were measuring the same auditory functions. The present study investigated the above relationship.

Purpose

The purpose of this study was to determine whether there was a predictable relationship between test results obtained by audiologists

for central auditory function and those obtained by speech pathologists for auditory language function. The performance of ten learning disabled children and ten normal children on the staggered spondaic word test and Willeford's tests of central auditory processing abilities was compared to their performance on the six auditory subtests of the ITPA.

Importance of the study

The results of the present study yielded information that was of diagnostic and therapeutic importance to speech pathologists. In diagnosing language performance it is important to know if deficits in certain auditory language skills indicate a need for further testing by an audiologist.

If tests of central auditory function and auditory language tests measured the same auditory functions, the approach to remediation of auditory dysfunctions would not vary, because the functions would be the same. If, however, the tests were actually tapping into different auditory functions, the techniques and approaches to therapy would also vary. In this case, central auditory dysfunctions and auditory processing problems would possibly be considered two distinct disorders. The results of this study provided information that was of clinical importance in determining what type of therapy is necessary in the remediation of auditory processing impairment.

Hypotheses

The following hypotheses are stated in the null form:

1. There will be no significant difference in the performance of learning disabled children and normal children on the six auditory subtests of the Illinois Test of Psycholinguistic Abilities.

2. There will be no significant difference in the performance of learning disabled children and normal children on the staggered spondaic word test and Willeford's tests of central auditory processing abilities.
3. No one auditory subtest or combination of auditory subtests of the Illinois Test of Psycholinguistic Abilities will predict performance on the staggered spondaic word and Willeford's tests of central auditory processing abilities.

Definition of Key Terms

Central Auditory System - the primary auditory reception center of the cerebral cortex which encompasses the superior temporal gyrus, bilaterally, particularly the middle and posterior portions.

Central Auditory Impairment - impairment of the cerebral cortex and subcortical areas, probably down to the level of the midbrain.

Learning Disability - a specific retardation or disorder in one or more of the processes of speech, language, perception, behavior, reading, spelling, or arithmetic.

Language Disorder - a disorder which affects a person's ability to comprehend or formulate his thoughts into appropriate words or sentences.

it must be recognized that one disorder may be basic to another.

Sabatino (1968) studied the information processing behaviors as associated with learning disabilities. He felt that there is evidence that clearly indicates that a learning disability may have multi-dimensional etiology. In his study, he attempted to describe some of the behaviors which might be responsible for learning. These were referred to as information processing behaviors.

Sabatino used 23 commonly used psychological tests and subtests as a tool for determining the information processing behaviors associated with learning disabilities. He administered these tests to 45 males, ages 6-4 to 12-2 years. The results indicated that the behaviors exhibited could be placed into four major categories: (1) a perceptual category containing various possible perceptual behaviors, (2) a symbolic mediation category, (3) a perceptual memory, spatial relations category, and (4) a language association category.

Eisenson (1966) stated that disturbances in the basic functions of language learning can result in hyperactivity, deficiency in attention span and communicative and education handicaps (language and learning disabilities).

Katz (1962, 1968) discussed a connection between learning disabilities, central auditory impairment and language deficits. He stated that a child may have perfect peripheral sensitivity but be limited in his understanding of what he hears from only a slight degree to almost total non-comprehension. A child with central auditory dysfunction may develop problems in the area of learning achievement, language development and personality adjustment if this dysfunction is not detected early.

Central Auditory Testing by Audiologists

During the past two decades many investigators have studied central auditory function. Various methods were used in testing for central auditory function, including tests consisting of filtered speech, competing messages, binaural resynthesis and alternating speech.

Bocca (1954) and his associates began devising special speech tests which stress the auditory system for purposes of detecting temporal lobe tumors. They devised a test in which the speaker's voice was filtered through a low pass filter set at 800 Hz. This distorted the message so that patients with tumors or lesions in one of the auditory cortices exhibited reduced discrimination scores for stimuli presented to the contralateral ear.

Cherry and Taylor (1954) first performed alternating speech perception tests by periodically switching the message from one ear to the other so that each ear received half of the message. This was a type of binaural fusion. Those who performed poorly on this test were considered to have central auditory problems.

Jerger (1960) compared the performance of patients with Parkinson's disease to the performance of controls using low pass filtered speech and speech with alternating masking index. He found that subjects with Parkinson's disease did not perform as well as the controls on either central auditory test.

Katz (1962) devised a test of competing messages using spondee words (staggered spondaic word test - SSW). In this test, the second part of the first word is presented simultaneously with the first part of the second word. A momentary pause separates the two individual

monosyllables of each of the two spondees in each test item. The order in which he responds is noted but not considered in the scoring.

Errors on the test consist of omissions, substitutions or distortions of any monosyllable. A few minor deviations are not considered to be an error, for example, "white wall" instead of "white walls." Errors are marked on a score sheet and analyzed later. Those who perform poorly on the SSW are considered to have central auditory dysfunction.

In 1968 Katz conducted a pilot study using the SSW. He compared subjects who had normal hearing, unilateral trauma to the head, conductive hearing loss and sensori-neural hearing losses. Control subjects with normal hearing and subjects with conductive hearing losses had little or no difficulty on the SSW. Subjects with moderate to severe sensori-neural loss showed a significant amount of difficulty on the SSW. The group with unilateral head trauma manifested the most difficulty. They demonstrated the greatest number of errors when the stimulus was presented to the ear contralateral to the injury.

Willeford (1976) devised the Willeford's tests of central auditory processing abilities. This test is comprised of 25 competing sentences that are of equivalent length and similar subject content. While data on this test is still being accumulated, Dr. George Lynn and his associates at the Wayne State University Medical School report that the results have been highly satisfactory. Whereas, normal individuals could repeat the test sentences correctly in nearly every case, patients with central auditory dysfunction generally missed all items presented to the ear contralateral to the hemisphere with the lesion.

Learning Disability and Central Auditory Testing

Katz and Illmer (1972) stated that the way in which a child is able to handle competing messages will have an important effect on his learning abilities. A person with normal auditory processing and integrating capacity has no difficulty perceiving and repeating what he hears, even when there is background noise. A subject with auditory figure-ground differentiation problems will experience difficulty in proportion to his impairment.

Stubblefield and Young (1975) conducted a study to compare the performance of 20 learning disabled children and 20 normal achieving children on the staggered spondaic word test (SSW). The experimental group consisted of children ages 7 - 11 years who had been referred from the College Educational Evaluation Center for the purpose of psychometric and educational testing. The children had been categorized as learning disables at their schools. The control group consisted of 20 children from a local elementary school who were judged by their teachers as being normal achievers in their studies. The children were matched to the experimental group according to age, sex, socioeconomic background and IQ. None of the children in either group had physical disabilities of any kind. The standard battery of tests for pure tone threshold sensitivity and speech audiometry was performed. No subjects were found to have any significant peripheral impairments. The SSW test was administered to both groups. The results showed that the control group (normal achievers) gave scores within the standardization of the norms. Those in the experimental group (learning disabled) did not. It was concluded from these findings that the SSW test for central auditory function may be an important tool in detecting learning disabled children at an early age.

Willeford (1976) tested the performance of nine children grossly labelled as learning disabled on the Willeford's tests of central auditory processing abilities. He found that the performance of these children was poor on one or more of the four tests in one or both ears. Willeford did not draw any conclusions but did say that there is a lot of work to be done in the area of auditory processing, especially with learning disabled children.

Auditory Processing Tests used by Speech Pathologists

Perhaps the test most commonly used by speech pathologists in measuring the auditory processing system is the Illinois Test of Psycholinguistic Abilities (ITPA). The ITPA (Kirk, 1971) was developed as a diagnostic tool that would meet a two-fold purpose: (1) to secure an adequate and complete diagnosis of children, and (2) to provide analytic information which may lead to remediation of the problems discerned.

The ITPA is divided into three dimensions: channels of communication, psycholinguistic processes of communication, and levels of organization of communication. The ITPA is also divided into ten subtests and two supplementary tests, six of which are auditory subtests. Each subtest is reported to measure one and only one descrete function. Each test is scored on a scaled score basis, thus making it possible to compare the scores across subtests. An experimental edition of the ITPA appeared in 1961. Over a three year period (1965-1968) the test materials and procedures were redesigned and the test restandardized. The revised edition of the ITPA appeared in the fall of 1968. The ITPA in final form was standardized on 700 children, ages 2 - 9 years (Kirk and Kirk, 1971). The auditory subtests will be reviewed in detail.

Auditory Reception - This subtest assesses the child's ability to derive meaning from verbally presented material. Vocabulary becomes more difficult as the test items progress. The function of determining meaning from syntax has been minimized by retaining only one sentence form (Representational level).

Auditory Association - This subtest assesses the child's ability to relate concepts presented verbally. The organizing process of manipulating linguistic symbols in a meaningful way is tested by verbal analogies of increasing difficulty (Representational level).

Grammatic Closure - This subtest makes use of the child's ability to utilize the redundancies of oral language in acquiring automatic habits for handling syntax and grammatic inflections (Automatic level).

Auditory Closure - This is a subtest of the organizing process. It assesses the child's ability to fill in missing parts which were deleted in auditory presentation and to produce and complete the word. Auditory closure is a function which occurs in everyday life in situations such as understanding foreign accents, speech defects, or poor telephone connections (Automatic level).

Sound Blending - This subtest provides another means of assessing the organizing process at the automatic level in the auditory-vocal channel. The child has to synthesize the separate parts of the word and produce an integrated whole (Automatic level).

Auditory Sequential Memory - This subtest assesses the child's ability to reproduce sequences of digits of increasing length from memory (Automatic level).

ITPA and Learning Disabilities

Olson (1961) compared the performance of 25 deaf and 27 sensory aphasic children on the ITPA (then called the Illinois Test of Language Ability). It was found that as a group, the deaf scored significantly higher than the sensory aphasics on four of the nine subtests. The results indicated that the ITPA is a useful diagnostic instrument capable of providing valuable information in the difficult task of differential diagnosis between deaf and sensory aphasic children.

Kass (1962) administered the ITPA to learning disabled children with normal intelligence. She found that these children performed poorly on the ITPA, specifically on subtests presented at the automatic level of communication.

Summary

The literature reviewed seems to support the idea that learning disabilities may occur in a variety of areas. Problems may be manifested in a specific area or in a combination of areas (Kass and Myklebust, 1969; Kirk, 1966).

The studies reviewed on the development of tests for central auditory function seem to indicate that these tests have been refined over the years and that they have been successful in identifying subjects with central auditory impairment. Katz (1968), Stubblefield and Young (1975), and Willeford (1976) state that there appears to be a connection between central auditory dysfunction and learning disabilities. The studies performed by Willeford (1976) and Stubblefield and Young (1975) showed that learning disabled children performed poorly on central auditory tests. Willeford concluded that there was a need for further investigation in this area.

The auditory subtests of the ITPA were considered. Olson (1961) showed that the ITPA may be useful in differentiating between deaf and sensory aphasic subjects. Kass (1962) used the ITPA in measuring auditory and visual performances of learning disabled children and found that these children performed poorly on the subtests presented at the automatic level of communication.

These studies appear to support the belief that there is a connection between learning disabilities, central auditory impairment and auditory processing deficits. However, none of the investigations reviewed discussed the possibility of a positive correlation between the measuring devices used in diagnosing central auditory dysfunction and those used in diagnosing auditory processing impairment. The present study investigated this relationship.

Chapter 3

METHODS

Description of the Sample

Ten learning disabled children served as the experimental group. The subjects varied in age from 7-0 to 10-3 years. The subjects in the experimental group had been diagnosed as learning disabled by the school district in which they were enrolled. Ten normal children served as control subjects. The child was considered to be normal if he did not exhibit behavioral or learning difficulties. The classroom teacher was the primary source for this information. The groups were matched for age, sex, and socioeconomic background. Only subjects with normal peripheral hearing and an IQ within normal limits were included in the study. Children with any physical or mental handicap other than that of learning disability were excluded from this study. A description of the subjects is presented in Appendix A.

Materials

The instruments of measurement used in the present study were the six auditory subtests of the Illinois Test of Psycholinguistic Ability (ITPA) (Kirk, 1971). These tests provided a basis for determining the presence or absence of auditory language deficits.

The ITPA is a diagnostic tool used to assess language deficits in learning disabled children (Kirk, 1966). The test consists of ten subtests and two supplementary tests, six of which measure the function of the auditory processing system.

For the purpose of this study, only the six auditory subtests were utilized. In these subtests, auditory stimuli were presented in the form of phrases, sentences, or digits to which the child was to give an appropriate response.

Procedures

The peripheral auditory system of all subjects was tested by an audiologist using the standard battery of air conduction sensitivity tests and speech audiometry. The staggered spondaic word test (Katz, 1968) and Willeford's tests of central auditory processing abilities (Willeford, 1976) were also administered by an audiologist. Cut-off scores for the tests used in this investigation are listed in Appendix B.

The six auditory subtests were administered following the standardized procedures in the ITPA Manual. Each subject was tested individually in a quiet, well-lighted room. The order in which the subtests were administered to each subject was determined by random selection. The results of the auditory subtests were scored and compared to the scores obtained by the same children on the SSW and Willeford's tests. The results of the two test batteries were analyzed statistically, using a t-test for related samples, a correlation matrix and a regression analysis. The findings and conclusions are reported in the following sections of this study.

Chapter 4

RESULTS

Mean Comparisons

The t-test for related samples was used to compare the performances of the experimental group and the control group on six tests of language performance and two tests of central auditory performance. One of the central auditory tests contains four tasks.

The results of this comparison are reported in Table 1. The subjects' raw scores on the tests of language performance and central auditory performance are reported in Appendix C. Significant differences were found between the performances of the two groups on the auditory reception subtest of the Illinois Test of Psycholinguistic Ability and on the Filtered Speech task of Willeford's test of central auditory processing abilities.

Correlation

The correlation matrix for all subjects is reported in Table 2. Strong correlations were found between the various subtests of the ITPA and between the central auditory tasks. A number of low to moderate correlations were found between the auditory language tests and central auditory tests.

Regression Analysis

A multiple regression analysis was used to identify the combination of tests which acted as best predictors of each test of language performance and each test of central auditory performance. Table 3 lists

Table 1

Mean Comparisons Between Experimental and Control Groups
on Tests of Language Performance and Central Auditory Performance

	Experimental		Control			
	Mean	SD	Mean	SD	t	p
Auditory Reception	27.8	8.06	36.2	3.73	t = 2.88	p < .05
Auditory Association	30.3	7.91	34.4	5.48	t = 1.95	p > .05
Auditory Sequential Memory	29.8	5.07	29.6	4.88	t = .076	p > .05
Grammatic Closure	26.4	8.12	33.2	6.95	t = 2.03	p > .05
Auditory Closure	31.8	12.32	32.1	9.72	t = .091	p > .05
Sound Blending	41.1	2.46	41.5	3.80	t = .299	p > .05
Staggered Spondaic Words	16.2	24.19	7.3	8.05	t = 1.31	p > .05
Competing Sentences (right ear)	76.0	32.04	97.0	4.83	t = 1.95	p > .05
Competing Sentences (left ear)	67.0	27.50	80.0	14.90	t = 1.36	p > .05
Filtered Speech (right ear)	63.0	17.72	77.6	11.30	t = 2.85	p < .05
Filtered Speech (left ear)	63.8	16.71	76.4	10.61	t = 2.82	p < .05
Binaural Fusion (right ear)	45.5	27.83	52.5	16.87	t = .835	p > .05
Binaural Fusion (left ear)	31.5	25.93	46.0	17.91	t = 1.19	p > .05
Alternating Speech	86.0	26.01	99.0	3.16	t = 1.53	p > .05

*t = 2.262 p: < .05

Table 2

Combined Subjects Correlation Matrix for Relationships Between Language Performance Variables and Central Auditory Performance Variables

ables	Variables													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	1.000	.635239	.280106	.658661	.396995	.260614	.555018	.47707	.324479	.113979	.186499	.077499	.171733	.427949
		1.000000	.44845	.627506	.536087	.570409	.575744	.258102	.166386	.059430	.119073	.265912	.115106	.154513
			1.000000	.432971	.479078	.332362	.650733	.442456	.515999	.167873	.150182	.499766	.171664	.440562
				1.000000	.638299	.454397	.64765	.585817	.463734	.176544	.223706	.19248	.205621	.497218
					1.000000	.417404	.735961	.518439	.555999	.147777	.315774	.285287	.317205	.47047
						1.000000	.2647	.074670	.067869	.041488	.101865	.067434	.207093	.030602
							1.000000	.797755	.820487	.416644	.55671	.484211	.42158	.739247
								1.000000	.833807	.717589	.792662	.578846	.571001	.953191
									1.000000	.584612	.658243	.609223	.553553	.786213
										1.000000	.919086	.653062	.527919	.699813
											1.000000	.361612	.500675	.598509
												1.000000	.562424	.599756
													1.000000	.781119
														1.000000

< .05

the variables. Table 4 lists the models built for the regression analysis. Included in Table 5 are the models used in the regression analysis. Numerous models have been excluded from Table 5. These models are eliminated because their R-squares were smaller than the ones presented in Table 5.

For the staggered spondaic word test, the auditory sequential memory subtest and the auditory closure subtest of the ITPA acted as best predictors. The test that served as best predictor for the binaural resynthesis subtest of Willeford's test was the auditory sequential memory subtest of the ITPA. However, this subtest predicted performance in the right ear only. Due to the low R-square, this subtest has marginal predictive value. No significant differences in level of prediction were found for any of the other tests.

Table 3

List of Variables

Number of Variables		Type
1	Auditory Reception	Independent Variable
2	Auditory	" "
3	Auditory	" "
4	Grammatic Closure	" "
5	Auditory Closure	" "
6	Sound Blending	" "
7	Staggered Spondaic Word Test	1st Dependent Variable
8	Competing Sentences - Right Ear	" "
9	Competing Sentences - Left Ear	" "
10	Filtered Speech - Right Ear	" "
11	Filtered Speech - Left Ear	" "
12	Binaural Resynthesis - Right Ear	" "
13	Binaural Resynthesis - Left Ear	" "
14	Alternating Speech	" "

Table 4

Regression Models

Model Number	Dependent Variable	Independent Variable	R - SQ
I	7 - 14	Mean of Dependent Variable	----
1	7	1 - 6	.625847
2	7	1 - 5	.621114
3	7	3 - 5	.6271
4	7	3, 5	.616661
5	7	5	.516174
6	8	1 - 6	.372169
7	8	1, 3, 4, 5	.266596
8	8	1, 4, 5	.281617
9	8	4, 5	.305297
10	8	4	.306691
11	9	1 - 6	.40755
12	9	3 - 5	.279072
13	9	3, 5	.318251
14	9	5	.270754
15	10	1 - 6	.383117
16	11	1 - 6	.289412
17	12	1 - 6	.031435
18	12	3	.208086
19	13	1 - 6	.257604
20	13	5	.050653
21	14	1 - 6	.290949
22	14	1, 3, 4, 5	.172637

Table 5

Comparison of Regression Models

Model No. vs. Model No.	F	df	P	Significance
3 - I	8.96898	(3, 16)	.0013	< .05
3 - 4	.447906	(1, 16)	.51918	> .05
4 - 5	4.45631	(1, 17)	.04752	< .05
6 - I	1.28437	(6, 13)	.32945	> .05
6 - 10	.27116	(5, 13)	.92011	> .05
11 - I	1.49046	(6, 13)	.2558	> .05
11 - 13	.489867	(4, 13)	.74529	> .05
13 - 14	1.18438	(1, 17)	.29182	> .05
15 - I	1.34561	(6, 13)	.30554	> .05
16 - I	.882451	(6, 13)	.53479	> .05
18 - I	4.72974	(1, 18)	.04105	< .05
19 - I	.751812	(6, 13)	.62026	> .05
19 - 20	.724777	(5, 13)	.61838	> .05
21 - I	.889061	(6, 13)	.53071	> .05
21 - 25	.313679	(5, 13)	.8956	> .05

Chapter 5

DISCUSSION

The present investigation was designed to test the hypothesis that there is a positive correlation between the results obtained from language tests presented verbally to the auditory channel and those obtained from central auditory tests. It was hypothesized that the performance of a child on auditory language tests should give some indication of his performance on central auditory tests. Of interest in the present investigation was the pattern of responses for both the learning disabled and control groups on these two types of tests. To test these hypotheses, the performance of ten learning disabled children and ten normal children were evaluated. The performances of the two groups on six auditory subtests of the Illinois Test of Psycholinguistic Abilities were compared with their performances on Katz's staggered spondaic word test and Willeford's tests of central auditory processing abilities. Willeford's test battery contains four parts: competing sentences, filtered speech, binaural resynthesis, and alternating speech perception.

It has been reported in the literature that children with learning disabilities perform poorly on the ITPA and on central auditory tests; however, no study has been conducted in an attempt to investigate the relationship between these two types of evaluations. The pattern of the performance of normal subjects as compared with that of the learning disabled subjects on both types of tests was considered. It was of interest to determine if the results of the two groups' performances

would reveal quantitative as well as qualitative differences on both types of tests.

Three statistical tests were used to interpret the data obtained from this investigation. First, a t-test for related samples was used to compare the performance of the experimental group to that of the control group. Second, a combined correlation matrix for the subjects was made. Third, a multiple regression analysis was used to identify the language tasks which acted as best predictors for each of the central auditory tasks used in this investigation.

The results of the t-test for related samples revealed that there were only two subtests on which the control and experimental groups differed significantly. These were the auditory reception subtest of the ITPA and the Filtered Speech test, both right and left ears, of Willeford's tests of central auditory processing abilities.

In the auditory reception subtest, the child must derive meaning from verbally presented material. The test seeks to evaluate the child's ability to recognize word meanings and is primarily involved with vocabulary. The Filtered Speech test evaluates the child's ability to fill in missing frequencies in order to construct whole words. The child hears a word in which the high frequency components above 1800 Hz have been filtered out. The underlying factor tested is the subject's ability to provide the portions of the signal which have been omitted in order to repeat the complete word.

The difference found between the performances of the control and experimental groups on these tests was significant at the .05 level of confidence. No significant differences were found in the performances of the two groups on any of the other five subtests of the ITPA or on

any of the other four audiological tasks used in this investigation.

It has been reported in the literature that children of low socioeconomic backgrounds do not perform as well on standardized language tests as do those from a middle or high socioeconomic environment. All the subjects in this study were of a low socioeconomic background. As already reported, both groups performed similarly on the auditory subtests of the ITPA. The control group, as a whole, did not fall below the normal limits set by Kirk on any of the subtests of the ITPA. The experimental group fell below these limits on only the auditory reception subtest of the ITPA. There were individual scores which fell below normal limits on various subtests, but no one child in either the experimental or control group fell below normal limits on all of the auditory subtests. Based on these findings it would appear that the low socioeconomic status of these subjects did not influence their performance on the auditory subtests of the ITPA.

Both the control and experimental groups performed poorly on the central auditory tasks. In an attempt to evaluate this finding in terms of low socioeconomic status, the study of Goldman and Sanders (1969) must be discussed. Goldman and Sanders observed that disadvantaged subjects of college age had 11 per cent failure on a pure tone screening test that had been performed in a university classroom. When these same subjects were retested under standard audiometrical conditions, only one of the 25 students failed the threshold test. Goldman and Sanders suggested that the inability to listen under less than ideal conditions might be a function of the environment in which these subjects were brought up. They speculated that these results might be due to high noise levels in culturally deprived neighborhoods. Therefore, children

who are reared in deprived environments may not be used to listening under unfavorable signal-to-noise-ratio conditions. This information indicates that the low socioeconomic status of these subjects may be a contributing factor in the poor performance of both groups on the central auditory tests, but low socioeconomic status did not appear to have influenced their performance on the auditory subtests of the ITPA.

It is also reported that learning disabled children perform poorly on the ITPA and the central auditory tests used in this investigation when compared with normal children. The question is raised as to why there was no significant difference between the performances of the control and experimental groups on the majority of the tasks on the two test batteries administered. In planning this investigation, it was anticipated that a random sample of children labelled "learning disabled" might not differ because the term learning disabled may be used in a variety of contexts. It might include those children who have only a problem in mathematics, visual perception, or some other specific problem. Because this investigation was to deal with the relationship between language tests and central auditory tests, it was imperative that the subjects in the experimental group exhibit a problem in the area of central auditory processing. For this reason, only children who fell below the norms on at least two of the five central auditory tasks were included in the experimental group. Three of the children in the experimental group failed all of Willeford's tests as well as the staggered spondaic word test. However, when the control group was tested for central auditory performance, it was found that no individual in this group passed all the central auditory tests. The two groups' performances differed only on the filtered speech task of Willeford's

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tests. No other significant differences were found between the two groups on any of the other central auditory tasks. According to the published norms, all subjects in this study, both the experimental and control groups alike, exhibited central auditory problems. In search of an explanation for these findings, the norming of the central auditory tests was brought into question. In a study by Myrick (1965), the central auditory ability of normal children, ages 5 - 12 years, was tested using the SSW. The results of this test indicated that as the age of the child increases, his performance on the SSW improved (Fig. 1). Despite this finding, the cut-off score is used for all age groups. This might be a partial explanation for the finding that the experimental and control groups performed similarly on the SSW. This may also be a key factor underlying the finding that all subjects, both normal and learning disabled, were identified as having central auditory problems. It is possible that age may also influence the performance of normals tested with Willeford's tests of central auditory processing abilities since both the SSW and Willeford's tests are similar tasks which tap into the central auditory system.

Neither the experimental nor the control groups fell below the norms on the auditory subtests of the ITPA; nor did their performances differ significantly on the central auditory tests. Based on these findings, one must question whether these children were exhibiting language processing problems. Because the performances of the experimental and control groups were virtually the same, no conclusions could be drawn concerning the relationship between the results obtained from the learning disabled subjects and those obtained from the normals.

Figure 1

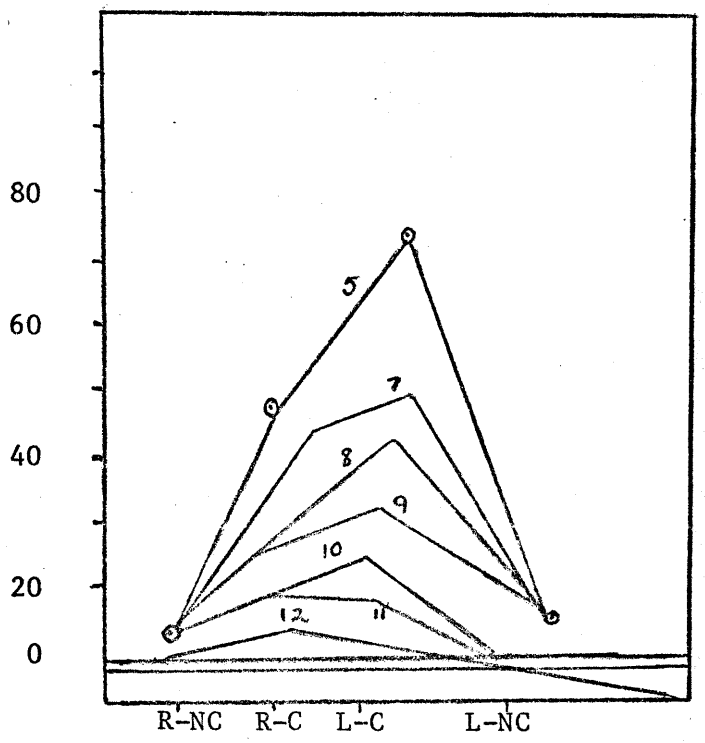

Fig. 1: C-SSW results for normal children. These represent the extreme upper limits of normal for various age groups (5, 7, 8, 9, 10, 11 and 12 years) and should not be taken as means. Myrick (1965).

However, this fact did not make it impossible to investigate the relationship of the performance of all the subjects on these two types of tests.

A correlation analysis was performed for the two groups as a combined whole. The results of this correlation indicated interrelationships between numerous subtests of the ITPA and interrelationships between all but one of the four parts of Willeford's test and the SSW. The results of this finding were consistent with data previously reported in the literature. This supports the idea that all auditory subtests of the ITPA are tapping into the same system and that the central auditory tasks are tapping into the same system. There were a number of low to moderate correlations between the various auditory subtests of the ITPA and the central auditory tasks, with the exception of the sound blending subtest of the ITPA. The sound blending subtest did not correlate with any of the central auditory tests. The auditory sequential memory subtest of the ITPA had the largest number of correlations with the central auditory tests. This may indicate that auditory memory plays a part in performance on central auditory tests.

The results of the multiple regression analysis indicated that no one language test served as the best predictor for any of the central auditory tests. However, it was found that a combination of two tests, the auditory sequential memory and auditory closure subtests of the ITPA, predicted performance on the staggered spondaic word test. Closer inspection of the skills underlying these tasks gives some insight into the existence of this relationship. In the SSW, two spondaic words are presented to the subject: the first part is presented to the right ear with no interference; the second and third parts are presented

simultaneously or in competition; and the fourth part is presented to the left ear with no interference. In order to make an accurate response on the SSW the subject must hold the entire stimulus in short term memory while separating the competing portions of the spondaic word. He must then identify and verbally produce each word. On the auditory sequential memory subtest, the subject is required to repeat a sequence of digits in the order in which they were verbally presented. The number of digits presented is increased until the subject fails two consecutive presentations of two sets of numbers. It appears that the auditory sequential memory subtest and the SSW both require immediate auditory recall of a sequence of words just heard.

In both the auditory closure subtest and the SSW the subject must reconstruct words that have been presented to the auditory channel. These words contain a limited number of auditory cues. Specifically, in the auditory closure subtest the subject must fill in parts of a word that have been omitted and reconstruct the word while utilizing fewer than the normal number of verbal cues. In the SSW, interferring stimuli are presented (two words presented simultaneously) to the auditory system. The subject must identify the words in the presence of interferring stimuli and repeat the words he has formulated. Based on this information, it appears that auditory memory and supplying omitted cues is fundamental to performance on the SSW.

Results of the regression analysis also revealed that the auditory sequential memory subtest of the ITPA predicted performance on the binaural resynthesis portion, right ear, of Willeford's tests. However, since the auditory sequential memory subtest did not predict performance on the left ear for the binaural resynthesis task, this

finding may be considered to be of marginal value. Since the tasks are the same for both right and left ears, the auditory sequential memory subtest should have predicted performance for the left ear as well as the right. It should be noted that there was a low R-square associated with the prediction. Therefore, this finding may be considered marginal. It is possible that a stronger relationship may have been found if a larger sample had been used. However, the current investigation did meet the minimum recommendations for use of a regression analysis. Specifically, it is recommended that the sample size used in a regression analysis is no less than three subjects for each variable used as a predictor. The present investigation used twenty subjects with six variables used as predictors. The fact that the majority of performances on the central auditory tasks could not be predicted by performance on the auditory language tests indicated that there may be underlying differences in the types of abilities being evaluated by the two types of tests.

Prior to collecting the data there seemed to be several relationships that might be anticipated. Yet, some of these expected relationships were not observed. For instance, the auditory closure subtest of the ITPA appears to be similar to the filtered speech subtest of Willeford's tests in that both the auditory closure subtest and the filtered speech test require the subject to provide omitted portions of a verbal signal in order to reconstruct and form a whole word. However, the auditory closure subtest was not found to be a predictor for the filtered speech task. A factor involved in this might be that the process by which sounds are eliminated on the auditory closure subtest differs from the high frequency filtration that occurs on the filtered speech

test. In the auditory closure subtest, whole phonemes are omitted. In the filtered speech test, high frequency sounds above 1800 Hz are omitted, leaving a more indistinct auditory cue than might be heard in the auditory closure subtest. This might serve to make the filtered speech test a more difficult task.

It was also believed that there might be a correlation between the sound blending subtest of the ITPA and the alternating speech portion of Willeford's tests of central auditory processing abilities. This was assumed because both tests involve the synthesis of sounds or parts of words to formulate complete words or sentences. However, no such correlation was observed between these two tests. This might lead to the assumption that these two tasks have underlying differences and require similar, but not identical skills.

Summary and Conclusions

The purpose of this investigation was to observe the performance of normal and learning disabled children on auditory language tests and central auditory tests. Of specific interest was the relationship between these two test batteries.

Results of the foregoing investigation revealed that:

1. The experimental and control groups differed significantly on only the auditory reception subtest of the ITPA and the filtered speech portion of Willeford's tests of central auditory processing abilities. No significant differences were found on any of the other tests.
2. Scores of both the experimental and control groups were below normal limits as established by the authors of the central auditory tests. Based on this finding, subjects

in both the experimental and control groups were found to have central auditory dysfunction.

3. The authors of the ITPA have designated a range of scale scores that are considered to indicate normal auditory language performance. The control group performed within the normal range set by the authors of the ITPA. The experimental group performed within normal range on all the auditory subtests of the ITPA with the exception of the auditory reception subtest. On this subtest the subjects' scores were within the range described by the authors as indicating a borderline deficiency.
4. In an attempt to predict performance on the central auditory tests it was found that a combination of the auditory sequential memory and auditory closure subtests of the ITPA predicted performance on the staggered spondaic word test. It was also found that the auditory sequential memory subtest of the ITPA predicted performance on the binaural resynthesis part of Willeford's tests. These were the only predictors identified. Most of the tests of central auditory function could not be predicted from the auditory language tests.
5. The low socioeconomic status of the subjects did not affect their performances on the ITPA. It is possible that the low socioeconomic status of the subjects was a contributing factor to their low performance on the central auditory tests. However, the lower scores may simply reflect the age of the

subjects, a factor which was not considered when the norms of the central auditory tests were established.

The implications of these findings are that:

1. One set of norms for all age groups may not be adequate to differentiate abnormal from normal in the area of central auditory performance.
2. The small number of predictors between the auditory language tests and the central auditory tests may indicate that these two types of tests are tapping into different systems and evaluating two different types of auditory processing.
3. When working with children who have been identified by the SSW as having central auditory difficulties, incorporation of tasks stressing auditory memory and filling in missing auditory cues may aid in the overall rehabilitation of these children.

Before further research into the relationship between auditory language tests and central auditory tests can be carried out, better norms are needed for the central auditory tests. When this has been accomplished, further investigation into the area of auditory language processing and central auditory processing is suggested.

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APPENDICES

APPENDIX A

DESCRIPTION OF SUBJECTS

APPENDIX A

Table 6: Description of Subjects

Subject	Sex	Chronological Age	Occupation of Head of Household
E - 1	M	8 - 11	Inspector - United Can Co.
E - 2	M	9 - 2	Retired Serviceman
E - 3	M	9 - 5	Machinest
E - 4	F	9 - 7	Shipyard Foreman
E - 5	F	9 - 5	Mechanic - Seven-Up Co.
E - 6	M	9 - 7	Pipe Fitter
E - 7	F	8 - 7	Owns Small Trucking Co.
E - 8	M	9 - 9	Financial Analyst
E - 9	M	9 - 4	Painter
E - 10	M	9 - 9	Electrician
C - 1	M	8 - 10	Mason
C - 2	M	9 - 3	Mechanic
C - 3	M	9 - 5	Industrial Worker
C - 4	F	9 - 1	Laborer
C - 5	F	9 - 2	Mechanic
C - 6	M	9 - 8	Auto Mechanic
C - 7	F	8 - 10	Owns Small Co.
C - 8	M	9 - 6	Auditor
C - 9	M	9 - 1	Fireman
C - 10	M	10 - 1	Auto Mechanic

* E - Experimental Group

* C - Control Group

APPENDIX B

SCORES INDICATING NORMAL FUNCTION ON AUDITORY LANGUAGE TESTS AND CENTRAL AUDITORY TESTS

APPENDIX B

Table 7: Scores Indicating Normal Function on Auditory Language Tests and Central Auditory Tests

Test	*Normal Range of Performance
I. Auditory Language Subtests	Scaled Score of 36 and above
II. Central Auditory Tests	
A. Staggered Spondaic Word Test	-4 to 5
B. Willeford's Tests of Central Auditory Performance	
1. Competing Sentences	90-100
2. Filtered Speech	74-98
3. Binaural Fusion	75-100
4. Alternating Speech	100

*These scores were established by the authors of the test.

APPENDIX C

RAW SCORES: AUDITORY LANGUAGE TESTS AND CENTRAL AUDITORY TESTS

APPENDIX C

Table 8: Subjects Raw Scores for Auditory Language Tests and Central Auditory Tests.

	Variables										
Exper. Subjects	Aud. Rec.	Aud. Assoc.	Aud. Seq. Memory	Gram. Clos.	Aud. Clos.	Sound Blend.	SSW	Competing Sentences	Filtered Speech	Binaural Resynthesis	Alternating Speech
1	29	34	38	30	36	43	10	R-100 L- 70	R-78 L-76	R-75 L-55	100
2	44	44	31	40	42	44	3	R -90 L- 60	R-64 L-62	R-45 L-10	100
3	24	24	32	28	29	37	10	R-100 L- 90	R-70 L-68	R-65 L-10	100
4	25	30	35	28	32	42	3	R- 80 L- 90	R-68 L-62	R-60 L-45	100
5	15	20	20	9	0	39	84	R- 0 L- 0	R-42 L-32	R-10 L- 0	30
6	25	30	32	31	26	41	6	R- 90 L- 80	R-74 L-76	R-55 L-20	95
7	35	42	29	29	39	43	10	R- 40 L- 50	R-30 L-38	R-25 L-20	45
8	24	22	26	26	37	44	12	R- 80 L- 80	R-68 L-74	R-35 L-60	90
9	23	30	29	19	42	38	7	R-100 L- 90	R-88 L-84	R-85 L-65	100
10	34	27	26	24	35	41	17	R- 80 L- 60	R-48 L-66	R- 0 L-50	100
Control Subjects											
1	35	32	25	32	40	37	8	R-100 L- 90	R-82 L-82	R-35 L-40	100
2	33	39	28	28	27	41	5	R-100 L- 80	R-82 L-86	R-65 L-60	100
3	29	38	26	35	29	42	8	R- 90 L- 60	R-74 L-76	R-50 L-40	90
4	34	31	26	40	42	43	15	R-100 L- 90	R-84 L-84	R-70 L-45	100
5	39	22	25	30	34	21	21	R-100 L- 70	R-66 L-60	R-25 L-30	100
6	41	35	30	26	21	41	2	R-100 L-100	R-88 L-84	R-70 L-75	100
7	38	40	32	45	50	48	4	R-100 L- 70	R-80 L-72	R-35 L-70	100
8	36	33	35	26	32	43	2	R- 90 L- 80	R-90 L-84	R-45 L-20	100
9	36	34	29	28	28	44	15	R- 90 L- 60	R-78 L-80	R-70 L-30	100
10	41	40	40	42	46	42	-7	R-100 L-100	R-52 L-56	R-60 L-50	100